Borego Mountain is an isolated hill just north of the Julian-Kane Springs highway, about seven miles east of San Felipe Narrows, and completely surrounded by the desert floor. It lies between the Vallecitos and the Santa Rosas, being about four miles from the former mountains and nine miles from the latter. The snail, however, is definitely related to the forms inhabiting the Santa Rosas. Although, as previously stated, this shell is very similar in outward appearance to *xerophila,* the genetic relationship of the two races can hardly be very close, as their ranges are forty miles apart, on different drainages, and another race, *indioensis,* occupies intervening territory.

EARLY TERTIARY MOLLUSCA FROM WYOMING

BY LORIS S. RUSSELL[1]

The pioneer work of the territorial surveys, and the early activities of the United States Geological Survey, brought to light a great series of non-marine Molusca from the Upper Crustaceous and Lower Tertiary rocks of the western states. This material, studied principally by F. B. Meek and C. A. White, was described in a number of government reports. The most valuable of these is White's "Review of the Non-marine Fossil Mollusca of North America."[2] Paleontologists of later years, however, have shown little interest in these continental mollusks, apparently because of the long geological range, as well as the marked variability, of many species.

Meanwhile, the succession of Tertiary formation in the west has become much better understood than in the days of Meek and White, largely as a result of the systematic study of mammalian faunas. Various field parties of the American Museum of Natural History, while engaged in collecting remains of mammals, obtained a large number of fossil shells, mostly from the lower Tertiary rocks of Wyoming and New Mexico. This material was described by Professor T. D. A. Cockerell, between 1912 and 1915, in the Bulletin of the American Museum of Natural His-

[1] Published with the permission of the Director, Geological Survey of Canada.

[2] U. S. Geol. Surv., 3rd Ann. Rept., pp. 403–486, 32 pls., 1883.

tory. Cockerell's studies revealed the presence of a rich and interesting molluscan fauna in the lower Tertiary rocks of north-western Wyoming. However, as the stratigraphy of the sediments was not clearly understood at that time, much of the historical significance of the fossils could not be recognized.

More recently the Princeton University Scott Fund expeditions have entered north-western Wyoming, and in the field seasons of 1927, 1928, and 1929, Professor W. J. Sinclair and Dr. G. L. Jepsen, of Princeton University, obtained, beside rich vertebrate collections, an important series of fossil Mollusca. These shells were turned over to the writer for study, and the results from the subject of the present paper. While few additions can be made to the faunas, as described by Professor Cockerell, it is hoped that systematic and stratigraphic revision now possible will be an important contribution to the history of North American non-marine Mollusca.

The writer is very much indebted to Professor Sinclair and Dr. Jepsen for the opportunity to study this fine collection. Dr. H. A. Pilsbry, of the Academy of Natural Sciences, Philadelphia, has rendered valuable assistance in the determination of relationships. Dr. C. A. Reeds, of the American Museum of Natural History, kindly placed at the writer's disposal most of the Wyoming material studied by Professor Cockerell. In addition, the writer has utilized the collections of the United States National Museum. The illustrations of this paper were prepared by the writer.

The stratigraphy of the lower Tertiary rocks of north-western Wyoming has been described in detail by Dr. G. L. Jepsen.[3] However, a general summary of the geological succession here will be attempted before proceeding to the systematic descriptions.

Above the Cretaceous, dinosaur-bearing, Lance formation of Bighorn and Clark's Fork basins there is a series of continental beds that have been called Fort Union. The Clark Fork mammalian fauna was discovered[4] in the upper portion of this series and is correlated with the Upper Paleocene (Thanetian). The

[3] Proc. Amer. Philosoph. Soc., vol. 69, pp. 480–499, 1930.

[4] Granger, W., Amer. Mus. Nat. Hist., Bull., vol. 33, art. 15, p. 204, 1914.

Princeton expeditions have obtained several faunas at lower horizons, including approximate equivalents of the Torrejon (Middle Paleocene) and Puerco (Lower Paleocene) of New Mexico. Numerous fossil shells were collected from the Torrejon portion of the series, which, for purposes of the present paper, will be designated middle Fort Union. A few specimens of mollusks were found in the upper, or Clark Fork, beds.

The lower Eocene, or so-called Wasatch, beds rest upon the Fort Union series. In some places angular unconformities are visible at the contact. Granger[5] divided the "Wasatch" into two stages, a lower or Sand Coulée, and an upper or Gray Bull. These two divisions were distinguished only by the apparent absence, in the lower, of the primitive perissodactyl *Homogalax* (*Systemodon*). As the Princeton expeditions found this genus to be sparingly represented in the Sand Coulée beds,[6] the name Gray Bull is applied to the entire "Wasatch" series of northwestern Wyoming, although it is convenient to designate the lower portion as "Sand Coulée." The Gray Bull strata, in turn, are overlain by the Wind River series, also Lower Eocene, but this does not enter into the present discussion.

The systematic descriptions, which follow, are separated into two sections, one dealing with the Paleocene, or Fort Union fauna, the other with that of the lowest Eocene, the Gray Bull beds.

As associated material was recorded as such in the field, it is possible to list several Fort Union (Paleocene faunules, each of which is a natural association of species.

Faunule from 20-foot sandstone lens, middle Fort Union, on south-west edge of Polecat Bench: *Unio* spp., *Viviparus retusus* (Meek and Hayden), and *Campeloma limnaeiformis* (Meek and Hayden) (?).

Faunule from middle Fort Union beds in range 99 west, township 56 north, section 11 or 12: *Unio wasatchensis* Cockerell (?), *Viviparus paludinaeiformis* (Hall), *Lioplax nebrascensis* (Meek and Hayden), and *Goniobasis tenuicarinata* (Meek and Hayden) (?).

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[5] *Op cit.*, pp. 203, 205.

[6] Jepsen, G. L., Proc. Amer. Philosoph. Soc., vol. 69, p. 119, 1930.

The fauna known from the middue Paleocene beds is, with one or two exceptions, a typical Paleocene assemblage, both as to the species present and the associations of species in faunules. Such a fauna possesses much closer relationships with the mollusks of the continental Upper Cretaceous formations of the west than it does with known faunas of the Lower Eocene. The middle Fort Union shells from north-western Wyoming represent, in almost every case, either descendants of species known in the Upper Cretaceous non-marine faunas or actual survivors of such species.

It should also be noted that only fluviatile and lacustrine genera are present in the middle Fort Union fauna of the present collection.

In contrast to the assemblage just discussed, the imperfect shells from the Clark Fork, or upper Fort Union, beds belong to one fluviatile and one terrestrial genus, and strongly suggest species of the Lower Eocene fauna.

The Lower Eocene faunules of associated species in the "Sand Coulée" and upper Gray Bull beds show a uniformity of composition that is in contrast to the associations in the underlying Paleocene.

Faunule from "Sand Coulée" beds in Little Sand Coulée basin, east of mouth of Pat O'Hara creek: *Helicina evanstonensis* (White), *Physa* sp., *Polygyra veternior* (Cockerell), *Gastrodonta coryphodontis* Cockerell, *Oreohelix megarche* Cockerell and Henderson, *Oreohelix grangeri* Cockerell and Henderson, *Gonyodiscus ralstonensis* (Cockerell), *Grangerella megastoma* Cockerell, and *Grangerella sinclairi* (Cockerell).

Faunule from "Sand Coulée" beds north of divide at head of Little Sand Coulée: *Viviparus wyomingensis* Meek, *Goniobasis carterii* Conrad, and *Oreohelix grangeri* Cockerell and Henderson.

Faunule from upper Gray Bull beds fifteen miles west of Basin near Omorlamphus locality: *Unio sinopae* Cockerell(?), *Helicina evanstonensis* (White), *Viviparus jepseni* Russell, *Planorbis storchi* Russell, *Physa bridgerensis* Meek, *Physa pleromatis* White, *Polygyra veternior* (Cockerell), *Oreohelix megarche* Cockerell and Henderson, *Oreohelix grangeri* Cockerell and Henderson, *Gonyodiscus ralstonensis* (Cockerell) and *Grangerella sinclairi* Cockerell.

Turning to the consideration of entire faunas, it will be seen from the locality data given for the various species that there is slight differences between the fauna of the "Sand Coulée" beds and that of the upper Gray Bull. *Goniobasis carterii* and the Viviparidae seem to be more common in the lower horizons, but otherwise the differences can be ascribed plausibly to the chances of collecting. We may consider, therefore, the Mollusca of the Gray Bull stage, using the latter term in the comprehensive sense here adopted, as constituting a single, well-marked fauna. The species of this Lower Eocene fauna are, with few exceptions, either confined to the Gray Bull beds, or are known elsewhere only from Eocene strata. As to habitat, almost three-quarters of the genera represented are terrestrial, and if species and individual specimens are considered, the aquatic element becomes almost insignificant.

The almost continuous section of lower Tertiary rocks in northwestern Wyoming contains abundant remains of non-marine Mollusca, which show the change from Paleocene to Lower Eocene faunas in a relatively local area. The oldest fauna is in the middle Fort Union, and consists of aquatic species, mostly of Paleocene and Upper Cretaceous affinities. Presumably the great change began in late Paleocene time for the next stage, the Clark Fork or upper Fort Union, contains a few shells of Eocene type. The Lower Eocene "Wasatch" or Gray Bull stage contains a fairly uniform fauna, predominantly terrestrial in habitat and of Eocene affinities. Several species present here also occur in later Eocene horizons, suggesting that when the fauna of the Wind River group is known it will be found to be essentially like that of the Gray Bull.

The cause of this profound change in molluscan fauna is almost certainly to be found in the elevation of the Rocky Mountains. While it is known that uplift went on intermittently throughout the Late Cretaceous and Paleocene, a very important time of orogeny occurred, as shown by unconformities, following the deposition of the Clark Fork stage. This elevation and accompanying change of climate, while probably not profound, were sufficient to drive out or destroy the aquatic faunas, and to provide the correct environment for a dominantly terrestrial fauna,

which was already migrating in, presumably from the north. It is reasonable to suppose that this fauna, in turn, was modified by the renewed uplift of late Eocene or Oligocene time.

SNAILS AS HOSTS AND CARRIERS OF NEMATODES AND NEMATOMORPHA

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Snails, in their rôle as intermediate hosts of parasites, are generally thought of as hosts of trematodes, more especially because some of these trematodes are of considerable economic importance. However, snails are also of considerable interest as hosts of nematodes. The nematode fauna of snails received attention from helminthologists at an early date, but the subject was subsequently rather neglected until within the past two years. Such peculiar phenomena as the ability of so-called "free-living" and plant-parasitic nematodes to survive passage through the intestine of snails, and the occurrence in snails of nematodes belonging to the same genera as nematodes found in Amphibia, have raised interesting problems in the host-parasite relationships of these nematodes.

This problem in snail-nematode relationship may be attacked, first, by separating the nematodes found in snails into six groups on the basis of the mode of life of the nematodes involved. These six groups are as follows: (1) Nematodes normally free-living (living upon decaying plant or animal matter) and plant parasites which may pass through the digestive tract uninjured; (2) nematodes living as obligatory parasites in the digestive tract; (3) nematodes living as parasitic larvae in the foot muscle and having a free-living adult stage; (4) adult nematodes living in the genital organs; (5) agamic nematodes and Nematomorpha which live in the body cavity and leave the host upon reaching maturity, subsequently passing the remainder of their life as